A real-time investigation of *Desulfovibrio vulgaris* response to oxygen stress

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Desulfovibrios are sulfate-reducing bacteria that have long been regarded as obligated anaerobes. However, ecological evidence indicates that they can colonize oxic regions of microbial mats, and survive even in the photic zone of cyanobacterial mats, which are characterized by extreme diurnal shifts in oxygen, from oxygen supersaturation during the light period to anoxic conditions in the dark. Here we describe a spectroscopic and microbiological study that reveals how *Desulfovibrio vulgaris* enters a new phenotypic state when confronted with a sudden influx of oxygen. Using SEM and TEM microscopy we observed that during the first 24-72 h of exposure to air *D. vulgaris* cells are negatively aerotactic, gradually they loose there flagella, and begin to elongate, by 20 days exposure they are 3-4 times larger and have a well developed exopolysaccharide sheath. At all times the cells were viable and recovered when put back under anaerobic conditions. Real-time analysis using Synchrotron Fourier Transform Infrared Spectromicroscopy demonstrated quantitative changes in peptides and saccharides in the living cells during exposure to air, suggesting the exact timing of changes observed microscopically. During the early phase of the exposure, we observed decreases in total cellular proteins as well as changes in the secondary structures of proteins that are indicative of the changing of the local hydrogen-bonding environments and the presence of granular protein. During the late phase of the exposure, we observed the production of polysaccharides, concomitant with the production of the external sheath. The S-FTIR also demonstrated that the cells were viable within the sheath at 20 days exposure.